GAS LIFT APPARATUS AND METHOD FOR PRODUCING A WELL

DESCRIPTION

BACKGROUND OF THE INVENTION

[Para 1] Field of the Invention. The present invention relates generally to subsurface well completion equipment for lifting hydrocarbons from subterranean formations with gas, and more particularly to a method and apparatus for unloading liquid from a gas well by injecting gas into the well via gas lift valves.

SUMMARY

[Para 2] One aspect of the present invention is a gas lift system for use in a subterranean well, comprising: (1) a packer having dual ports, (2) a tubing string running from the surface to the packer for producing the well from a zone below the packer via a port in the packer, and (3) a tubular member running below the packer and including at least one gas lift valve for injecting gas into the well at a zone below the packer via the other port in the packer.

[Para 3] In another aspect of the present invention, the tubular member extends from the packer downward to a perforating interval of the well.

[Para 4] In yet another aspect of the present invention, the tubing string includes at least one gas lift valve for injecting gas into the well at a zone above the packer.

[Para 5] Other or alternative features will be apparent from the following description, from the drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 6] The manner in which these objectives and other desirable characteristics can be obtained is explained in the following description and attached drawings in which:

[Para 7] Figures 1-4 illustrate an embodiment of the gas lift system of the present invention for inserting gas into a well with gas lift valves located proximate to the perforation interval.

[Para 8] Figures 5-6 illustrate an embodiment of the gas lift system of the present invention for inserting gas into a well with gas lift valves located both proximate to the perforation interval and above the perforating zone to unload a liquid from the well.

[Para 9] Figures 7A-7C illustrate an embodiment of the present invention for deploying a gas lift system in a gas well at the perforating interval.

[Para 10] It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for

the invention may admit to other equally effective embodiments.

DETAILED DESCRIPTION

[Para 11] In the following description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[Para 12] In the specification and appended claims: the terms “connect”, “connection”, “connected”, “in connection with”, and “connecting” are used to mean “in direct connection with” or “in connection with via another element”; and the term “set” is used to mean “one element” or “more than one element”. As used herein, the terms “up” and “down”, “upper” and “lower”, “upwardly” and downwardly”, “upstream” and “downstream”; “above” and “below”; and other like terms indicating relative positions above or below a given point or element are used in this description to more clearly describe some embodiments of the invention. However, when applied to equipment and methods for use in wells that are deviated or horizontal, such terms may refer to a left to right, right to left, or other relationship as appropriate. Moreover, the term “sealing mechanism” includes: packers, bridge plugs, downhole valves, sliding sleeves, baffle-plug combinations, polished bore receptacle (PBR) seals, and all other methods and devices for

temporarily blocking the flow of fluids into or out of perforations in the formation.

[Para 13] Artificial lift systems are used to assist in the extraction of fluids from subterranean geological formations. For example, in gas wells, water is often produced with the gas and may accumulate at the bottom of the wellbore. If the column height of water in the well yields a greater hydrostatic pressure than the gas flowing from the formation, then the gas formation pressure becomes insufficient to move the gas in the well and hence gas production is hindered and/or decreased. In wells where this type of production decrease occurs, or if the formation pressure is low from the outset, artificial lift is commonly employed to enhance the recovery of gas from the formation. The present invention is primarily concerned with one type of artificial lift called “gas lift.”

[Para 14] In order for gas to be produced utilizing gas lift, a precise volume and velocity of the gas flowing upward through the tubing must be maintained. Gas injected into the hydrostatic column of fluid (e.g., water) decreases the column’s total density and pressure gradient, allowing the well to flow. As the tubing size increases, the volume of gas required to maintain the well in a flowing condition increases as the square of the increase in tubing diameter. If the volume and velocity (i.e., critical velocity) of the gas lifting the fluid is not maintained, the fluid falls back down the tubing, and the well suffers a condition commonly known as “loading up.”

[Para 15] In general, the present invention regards a gas lift system and method of use for injecting gas in a gas-bearing

well to unload a fluid. An embodiment of the gas lift system of the present invention includes an injection tool including one or more gas lift valves for injecting gas into a column of fluid within the perforation interval of a gas well. The injection tool is deployed downhole via a sealing mechanism -- such as a dual-port packer -- installed above the perforation interval. One port of the packer communicates the produced gas and fluid from the perforation interval to the surface via a string of tubing. The other port of the packer communicates an injection gas from the surface to the perforation interval via the deployed injection tool.

[Para 16] An embodiment of the gas lift system may be used for unloading an accumulated liquid (e.g., water, oil, and/or other well fluids) from a well having a perforation interval proximate a gas-bearing formation gas-bearing. If the hydrostatic pressure of the accumulated liquid exceeds pressure of produced gas, then the gas may not be produced. In operating the gas lift system, the formation is sealed using a sealing mechanism (e.g., a dual-port packer) in the well at a location above the perforation interval. A tubing string is provided for establishing communication between the surface and the well zone below the sealing mechanism. A gas injection tool having one or more gas lift valves is deployed in the well and provides communication between the surface (or a point above the sealing mechanism) and the perforation interval. A high-pressure gas is delivered from the surface into gas injection tool and into or proximate the perforation interval via the gas lift valves. By injecting gas in near the perforations, the hydrostatic pressure of the accumulated

liquid may be reduced to a level sufficient to permit gas to be produced from the formation. The rising gas and liquid may be unloaded from the well via the tubing string.

[Para 17] More particularly, with respect to Figure 1, an embodiment of the gas lift system of the present invention for unloading liquid from a gas well 10 includes an injection tool 60 having one or more gas lift valves 62A, 62B, 62C. The gas well 10 includes a casing 10 running from a surface location 12 through a gas-bearing formation 14 having perforations 24 therethrough. A dual-port packer 30 is provided to separate the well 10 into zones 10A and 10B. Zone 10A is typically a non-producing zone, while zone 10B typically includes a producing perforating interval. The wellhead 22 includes a mechanism for removing produced gas and fluid from the well 10 and a mechanism for providing gas to the well. The mechanism for removing produced gas and fluid from the well 10 is a tubing string 40 running from the surface 12 to zone 10B via a port in the packer 30. The mechanism for providing gas to the well is a gas line 50, which may include a valve 52 for controlling the inflow of gas into zone 10A of the well 10. The injection tool 60 is installed in the other port of the packer 30 and injects gas via the gas lift valves 62A, 62B, 62C into zone 10B of the well 10 proximate the perforations 24. The injection tool 60 may be a pipe, tubing, or other conduit with one or more gas lift valves for communicating between the annulus within the tool and the wellbore. Any type of gas lift valve may be employed in this operation including, but not limited to, injection pressure operation (IPO) valves, production

pressure operated (PPO) valves, proportional response (PR) valves, and other gas lift valves.

[Para 18] In operation, with respect to Figures 1-4, in the event that the well 10 is loaded up with a fluid (e.g., water) such that the velocity of the gas from the formation 14 falls below a critical velocity, gas may be injected into the well at or near the perforations 24 using the injection tool 60 to reduce the density and thus the pressure head of the fluid to re-achieve a production gas flow rate above the critical velocity. To accomplish this, a gas is introduced into the zone 10A above the packer 30 via a gas line 50 by actuating the valve 52. Once the gas pressure within the zone 10A above the packer 30 surpasses the selected actuating pressure to actuate the gas lift valve 62A, the valve 62A will open and gas will be injected into zone 10B of the well 10 proximate the perforations 24 (Figure 2). As gas pressure is steadily increased, the next lower gas lift valve 62B is opened and the higher gas lift valve 62A is closed such that gas is injected into the well 10 proximate the perforations 24 at an even lower depth (Figure 3). Finally, as gas pressure is further increased, the lowest gas lift valve 62C is opened and the higher gas lift valve 62B is closed such that gas is injected into the well 10 proximate the perforations 24 at a still lower depth (Figure 4). The injection of gas at these depths (e.g., 5,000 ft below the surface or more) lowers the density of the fluid and thus facilitates unloading the fluid from the well to re-achieve super critical gas velocities. Furthermore, by lowering the hydrostatic pressure in the well at the perforations 24, the

recovery of gas is facilitated by reduction of cross-flow and thief zone occurrences.

[Para 19] With respect to Figures 5-6, in another embodiment of the gas lift system of the present invention, the tubing string 40 includes valves 42A, 42B for unloading accumulated annular liquid from zone 10A above a dual-port packer 30. Also, an injection tool 60 having one or more gas lift valves 62A, 62B, 62C is installed below the packer 30 as described in the embodiments above. This system allows for providing unloading annular fluid in zones 10A and 10B. In operation, a gas introduced into the zone 10A above the packer 30 via a gas line 50 may actuating the valve 52. Once the gas pressure within the zone 10A is increased to a predetermined level, valve 42A will open and the accumulated liquid level in zone 10A will begin to drop as liquid is unloaded to the surface 10. As gas pressure is steadily increased, the next lower valve 42B is opened and the higher valve 42A is closed such that liquid may be unloaded at an even lower depth. Finally, once the annular zone 10A above the packer 30 is unloaded, gas may be injected into zone 10B of the well 10 proximate the perforations 24 as described above and shown in Figures 1-4.

[Para 20] While embodiments of the gas lift system and injection tool have been described with respect to unloading fluid (e.g., water) from a perforation interval to produce gas from a gas-bearing well, it is also intended that other embodiments of the present invention include a gas lift system and injection tool for injecting gas into a perforation interval of an oil-producing well to facilitate lifting oil from the formation to a surface location.

[Para 21] With respect to Figures 7A-7C, an injection tool 100 having gas lift valves 102 may be installed in a well 110 using a surface rig 120 (e.g., a workover rig). The injection tool 100 may be deployed by a line 130 (e.g., wireline or slickline) or conveyed on a tubing string. In the embodiment shown in Figure 7A, the injection tool 100 is connected to a line 130 via a connector 104. In some embodiments, the connector 104 is a hook or latch mechanism allowing the tool 100 to be retrieved once deployed downhole. The injection tool 100 is run down hole on the line 130 and deployed through a port in a packer 140. A production tubing string 150 may be deployed through another port in the packer 140. The injection toll 100 is installed in the packer 140 such that the gas lift valves 102 are arranged at a depth proximate a perforation interval 160 in the well 110.

[Para 22] Although only a few exemplary embodiments of this invention have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the following claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Thus, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface, in the environment

of fastening wooden parts, a nail and a screw may be equivalent structures. It is the express intention of the applicant not to invoke 35 U.S.C. § 112, paragraph 6 for any limitations of any of the claims herein, except for those in which the claim expressly uses the words ‘means for’ together with an associated function.